Revegetation
Lesson 5
Greenhouse, Field Sites, Classroom

Seed Germination and Seedling Growth

Learner Outcomes

The learner will

- Use standard methods to germinate small and large seed.
- Collect mesquite seedpods or beans, extract and germinate seed.
- Collect different soil types and plant seed at different soil depths.
- Collect data from germination and emergence studies.
- Summarize and statistically analyze data.

Background

Approximately 100 years ago, plants with large seed began to increase in the Chihuahuan Desert. Field data from west Texas, southern New Mexico and northern Mexico indicate that populations with large seed are rapidly increasing on sandy soils and slowly increasing on clayey soils. In the following studies, students will evaluate the impacts of temperature and soil on the germination and seedling emergence of both large and small seeded plants.

Activity #1
Seed Germination
5 class periods
(2 periods to set-up, then 10 - 20 minutes 3 times each week for 2 weeks)

Materials

- Supplement number 2.30
- Petri dishes and Whatman # 1 filter paper
- Seed packets of blue grama *(Bouteloua gracilis),* sideoats grama *(Bouteloua curtipendula),* alkali sacaton *(Sporobolus airoides)* and mesquite *(Prosopis juliflora)*
- Germinate seed at three to five temperature and light regimes using a seed germinator. If a germinator is unavailable contact a local extension specialist, university, USDA-Natural Resources Conservation or USDA-Forest Service office and ask for advice on where to find a germinator.
- Inch and metric rulers
- Dissecting microscope
- Five sheets of standard graph paper
- Calculator

Assessments

- Teacher observation
- Student notes recorded in field journal

Procedure

The teacher will

- Identify the project purpose using the grant proposal.

- Discuss how to add the Whatman paper to the petri dish, and the proper procedure for adding water to petri dishes.
- Provide students with the following instructions:

1. Open seed packet and place contents in separate petri dishes-make sure petri dishes are dry.
2. Place the petri dish under a dissecting microscope and count seed. Emphasize seed size differences
3. Place a single sheet of Whatman #1 filter paper in each of 5 petri dishes, and place 20 seeds of a single plant species on each of the 5 papers. Complete this process for each species.
4. Return remaining seeds to the seed packet and store in a refrigerator.
5. Along the outer edge of each petri dish, slowly add 10mL of distilled water.
6. Set germinator to one of the following 5 temperatures: 15, 20, 25, 30 and 35^0C. If a seed germinator is unavailable, use a thermometer to locate positions in the classroom where temperatures correspond to one or more of the desired temperatures. **For example**, daytime temperatures in August, September and May on inside classroom window sills often range between 30 and 35^0C, while at the same time temperatures near the floor of a back classroom wall will vary from 20 to 25^0C.
7. On Monday and Friday, remove petri dish lids, count germinated seed and record results on the **provided data sheet**. A seed is considered germinated when the radical or the root is more than 0.5cm.

- Use **Example 1** to explain the steps needed to analyze data for each temperature.
- Instruct students to determine the germination mean for each species at the 5 temperatures (Step 2 of Example 1). Along the y-axis of the graph paper, plot the percent germination, and along the x-axis plot the temperature.

Activity # 2

Preparing Mesquite Seedpods or Beans for Germination Studies

4 class periods

Materials

- Supplement number 2.31
- One plastic grocery bag full of mesquite seedpods or beans
- Drying oven
- Petri dishes
- Dissecting microscope
- Toenail clipper
- Paper hand towels (type of towels used in school restrooms, not those for home use.)
- One sheet of graph paper

Assessments

- Teacher observation of student participation

- Data Sheet (Supplement 2.31)

Procedure

The teacher will

- Assign students to collect mesquite seedpods after school.
- Address the issue of livestock preference for the mesquite seedpods, and that scientific evidence clearly shows that mesquite seed germinate better after traveling through the digestive tract of a cow. Increased germination occurs because the cow removes the seedpod pulp while chewing, and the seed is scarified during the chewing and digestive processes (Note: This may be a good time to mention that a cow chews food more than once and this animal has four stomachs).
- Have students either cut or break seedpods into individual bean segments.
- Instruct students to remove the outer pulp with a knife. **Follow safety precautions and keep the knife blade pointed away from the body, hand and fingers.** Once the outer pulp is removed a sticky-sugar substance and a tough paper envelope will cover the seed.
- Have students place seed on paper towels and dry in an oven at 40-50^{0}C for 5 to 10 days.
- Instruct students to follow procedures in Activity #1 - Seed Germination.
- Instruct students to use the toenail clipper to remove a small portion of the outer seedcoat of the mesquite seed, and place 20 seed in each of 5 petri dishes. Germinate using procedures in Activity #1 - Seed Germination.
- Have students use the Supplement 2.30 to organize data, and analyze data using the statistical procedure outlined in Example 1.

Activity #3

Seedling Emergence

7 class periods

Materials

- Supplement numbers 2.31 and 2.32 copied three times for data collection on days 7,14 and 21.
- Three soil collections: sand, silt and clay (**Note:** Contact a local USDA-Natural Resources Conservation Service Office and request that a soil scientist accompany students when collecting the three soil types).
- Drying oven
- 81, 150 X 150mm tapered plastic pots
- Seed packets of blue grama, sideoats grama and mesquite
- 27 petri dishes
- Sharpie permanent marker
- Inch and metric rulers
- Greenhouse
- 10, 0.15 X 1.50 X 2.25m sheet metal pans made of 16 or 18 gauge galvanized steel with a 25mm hole drilled 30cm from one corner
- 25mm stoppers
- Paper and pen or pencil
- Calculator

- Newspaper sheets or butcher paper

Assessments
- Teacher observations of student labeling pots, planting seed
- Data Sheet (Supplement 2.32)

Procedure
The teacher will give students the following instructions:
- Screen soils through a 5mm sieve and dry soil at 50^0C for five days. (Note: If requested, USDA-Natural Resources Conservation Service soil scientists will provide sieves and aid in screening)
- Divide pots into three equal groups of 27; **then** divide 27 into 9 equal groups of 3.
- Place the ruler at the bottom of the pot and on nine pots measure and mark 97 and 127 mm. On nine other pots measure and mark 117 and 127mm and on the remaining nine pots measure and mark 127mm.
- Place a folded paper towel in the bottom of each pot and **add the sandy soil** to all 27 marked pots. Add soil to the lowest or only marked line and gently drop each pot from approximately 10cm to allow the soil to settle; then refill to the line (Note: With the Sharpie write soil type and distance to the lowest mark on the outside of each pot.)
- Place 25 seeds of a single species in each of nine petri dishes and repeat the process for the remaining two species, for a total of 27 petri dishes (Be sure to **scarify mesquite seed** with the toenail clipper).
- In each of the nine pots filled to 97mm, place one of the following prepared petri dishes: three petri dishes with blue grama, three petri dishes with sideoats grama, and three petri dishes with mesquite. (Note: Now add the name of the species to be planted on the outside of each pot). Repeat the exact process in the pots marked 117mm and 127mm.
- After checking to insure accuracy, remove the petri dish lid and distribute seed over the soil surface.
- Fill 18 pots to the 127mm mark. Now seed are either on the soil surface or buried 10 and 30mm beneath the soil surface.
- Repeat the process for the silt soil, be sure to keep pots of sand separate from silt soil.
- Repeat the process for the clay soil, keep pots of clay soil separate from silt and sand soils.
- Select one pot with each of the following labels:

Species	**Soil**	**Depth**
Blue grama		
	sand	0
	sand	10
	sand	30
	silt	0
	silt	10
	silt	30

	clay	0
	clay	10
	clay	30
Sideoats grama		
	sand	0
	sand	10
	sand	30
	silt	0
	silt	10
	silt	30
	clay	0
	clay	10
	clay	30
Mesquite		
	sand	0
	sand	10
	sand	30
	silt	0
	silt	10
	silt	30
	clay	0
	clay	10
	clay	30

- Place all of these pots in two or three pans; label **Replication 1**
- Repeat the process, placing these pots in two or three separate pans; label **Replication 2**
- Repeat the process, placing these pots in two or three separate pans; label **Replication 3**
- Place stoppers in holes, and fill pans to 10cm with distilled water, check water height every 3 to 8 hours the first day and every 12 to 24 hours thereafter
- Place newspaper or butcher paper over the tops of pots to reduce evaporation
- Provide plants with 16 hours of light each day, and maintain the greenhouse temperatures between 25 and 30^0C.
- After 5 - 7 days remove paper, check seedlings and drain pans (It may be necessary to replant if seed fail to germinate and emerge).
- After five days replace stoppers, and refill pans to 10cm. Hold water level for three or four days and then drain. The subirrigation process works best and is most convenient if pans are filled on Friday afternoon and drained on the following Monday morning.
- After plants are 3 weeks of age, add 0.5kg of dry 10-15-10 fertilizer to each pan and add water to a height of 10cm. This process is to be repeated weekly until the experiment is terminated.
- On days 7, 14 and 21, count the number of seedlings in each pot and add data to supplement number 2.31.

- In addition to counting seedlings, measure the height of the three tallest seedlings, average the three numbers and record the number on supplement number 2.31. On graph paper plot the height of plants during the experiment. Be sure to average plants in a pot, then average plants in the same pot in each of the three replications. Note: Using a different color for each species, connect points on the graph.
- Determine changes in plant heights for each plant type or species, and prepare and evaluation of plant growth and development during the experiment.

Activity #4

Field Activities at Carlsbad Caverns National Parks

hours/days vary

Materials

- Materials will vary depending upon the project tasks to be performed.
- GPS Unit
- Spade
- Water pump, water
- Transplants in cone-tainers

Assessments

- Teacher observation of student's participation in field

Procedure

The teacher will

- Contact the park's Education Specialist to make arrangements for a meeting with the Carlsbad Caverns National Park's Resource Management Division. National Park Service staff will direct restoration with assistance from the students.
- Invite a National Park staff member to the school to discuss the project and field protocol.
- Have the students use the GPS unit in the field, to determine and record the location of each transplant/collection site/survey site.
- Instruct students to use a hand spade to remove soil from prepared holes.
- Have students extract the transplant from the cone-tainer and place them in the holes.
- Have students hand pack the soil around each transplant so that the transplant medium surface and the soil surface within the hole are depressed 1 to 2cm below the soil surface.
- Have students water the plants immediately after transplanting.
- Have students water plants periodically, depending on the season, the rainfall and other factors.

Activity #5

Long-term Plant Evaluation at Carlsbad Caverns National Park

hours/days vary

Learner Outcomes

The learner will

- Visually observe each transplant and determine if the plant is alive or dead.

- Monitor plants using photography, transects, or combinations with other monitoring techniques.
- Use simple statistical procedures to evaluate data and graph long-term trends in plant survival.

Materials
- Paper
- Clipboard
- Data Sheets
- Pen or pencil
- Calculator
- Measuring devices
- Camera
- GPS Unit
- Computer with spreadsheet or data base software
- Water pump, water

Assessments
- Calculations
- Photographs

Procedures
The teacher will
- Have students take measurements to determine basal area, plant height and seed production. Students should record all information on the Newton/Fieldworker.
- Have students determine the survival rate by counting live/dead plants in early fall and spring. Students should record data on the Newton/Fieldworker
- Instruct students to take photographs from specified locations quarterly for monitoring plants.
- Instruct students water plants when appropriate.
- Instruct students to calculate the number of live plants. Place the summary of each plant in the designated area of lined paper. Students are to determine and graph the mean for each plant type or species at each evaluation date.

NOTE: Activities #6 and #7 are not Chihuahuan Desert Lab activities at Carlsbad Caverns and Guadalupe Mountains National Parks. If your school is participating in revegetation programs that allow students to fence and/or plow experimental plots, you may wish to follow the procedures listed in Activities #6 and #7 for field site preparation, planting and evaluation.

Activity #6

Field Site Preparation and Planting

hours/days vary

Materials
- 50 X 50m site with vegetation removed, and the surface plowed to 30cm

- 2.5m fence to exclude rodents, deer and domestic livestock
- 1.0m chicken wire fence buried 50cm in the soil and attached to the 2.5m fence
- wood or rebar stakes (60cm in length and at least 2cm in diameter)
- 100m tape
- Power-driven auger

Assessments
- Teacher observation of student's participation in field

Procedure
The teacher will
- Make arrangements to have the site prepared prior to transplanting. If the site is on agricultural land, land preparation will follow standard agricultural production techniques. If the site is on rangeland the existing vegetation must be removed and the site plowed to 30cm and leveled.
- Two weeks prior to transplanting, have students count the number of different plants to be planted and multiply that number by 3. This will be the number of lines to be established at the site.
- Explain to students that if there are 10 different plants, thirty 10-m lines spaced at 50-cm intervals will be necessary. See notes below for more details.

Notes
- Place a stake at both ends of each line.
- In lines 1 to 10 plant each of the 10 plant types or species in separate line.
- Repeat the process in line 11 to 20, and lines 21 to 30.
- Lines 1 to 10 represent Replication 1.
- Lines 11 to 20 Replication 2.
- Lines 21 to 30 Replication 3.
- At 50-cm lengths along each line or at 20 equally distant locations along each line use the power-driven auger to drill 15 X 35-cm holes.
- Wait for a 20 to 35mm rainfall event to moisten holes, and then with a hand garden spade remove soil from the hole, extract the transplant from the "cone-tainer", and place the transplant in the hole. Fill around the transplant with moist soil and make sure the transplant surface and the moist soil around the transplant are depressed 1 to 2cm below the surrounding soil surface.
- Water each transplant site with 1L of tap water.

Activity #7
Long-term Plant Evaluations
twice a year

Learner Outcomes
The learner will
- Visually observe each planted hole and determine if plants are alive or dead.
- Use simple statistical procedures to evaluate data, and graph long-term trends in plant survival.

- Determine the mean for each plant type or species at each evaluation date and graph.

Materials
- Supplement numbers 2.33 through 2.37 (copy as needed for further study, making changes for the corresponding months)
- Clipboard
- Data sheets
- Pen or pencil
- Calculator

Assessments
- Calculations

Procedure
The teacher will
- Instruct students to count the number of live plants in each row in spring and fall, and record on the provided data sheet for three years -- six dates and three rows of the same plant at each date, for a total of 18 sheets for each plant type or species.
- Instruct students to calculate the number of live plants, and place the summary for each plant in the three replications on lined paper in a group of three. Students are to determine and graph the mean for each plant type or species at each evaluation date.

Activity #8
Post-test
20 minutes

Procedure
The teacher will
- Administer post-test to assess knowledge gained.